

Robotic Control through Neuroevolution

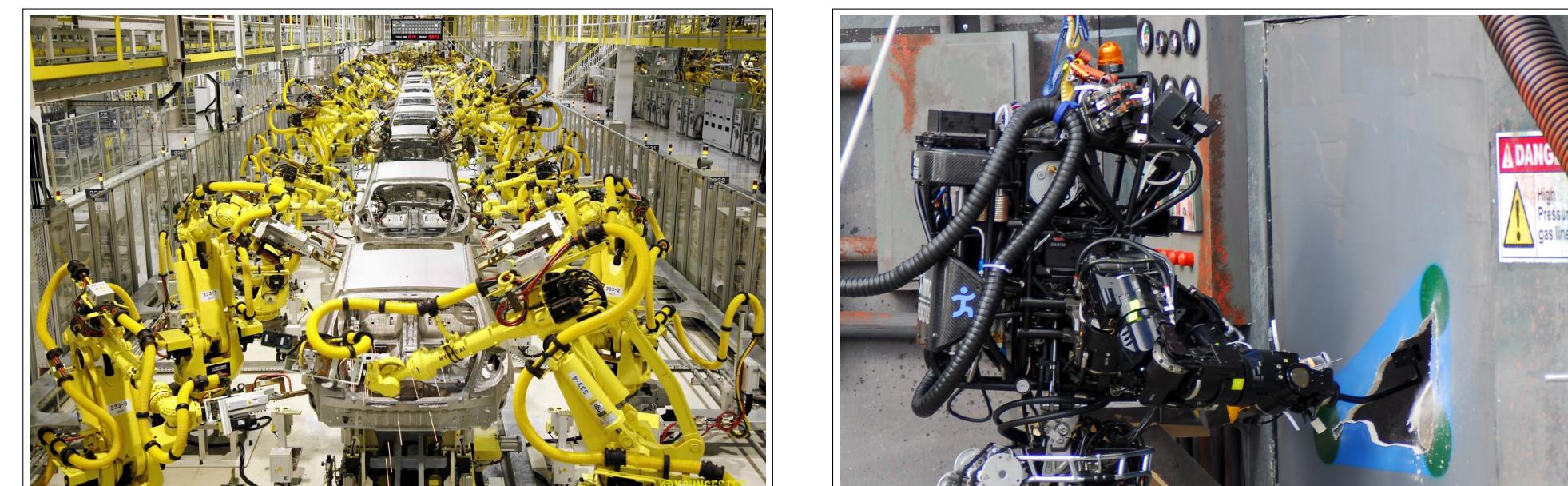
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Abstract

Traditional industrial robotics is primarily focused on optimal path control. In contrast, modern robotic tasks increasingly require greater degrees of adaptability and flexibility to deal with variations in the robot's environment. Moreover, new robotic tasks can be specified without precise models or target behaviors. Neuroevolution of robotic controllers is a promising approach to such tasks: Neural networks represent nonlinear control naturally and evolutionary computation creates robust and flexible solutions. This poster presents early results from experiments using a neuroevolution method called NEAT to evolve a low-level controller for joints on the Atlas humanoid robot. Results show that the choice of neural network architecture can make a difference on controller performance.

Industrial Robotics vs New Robotics



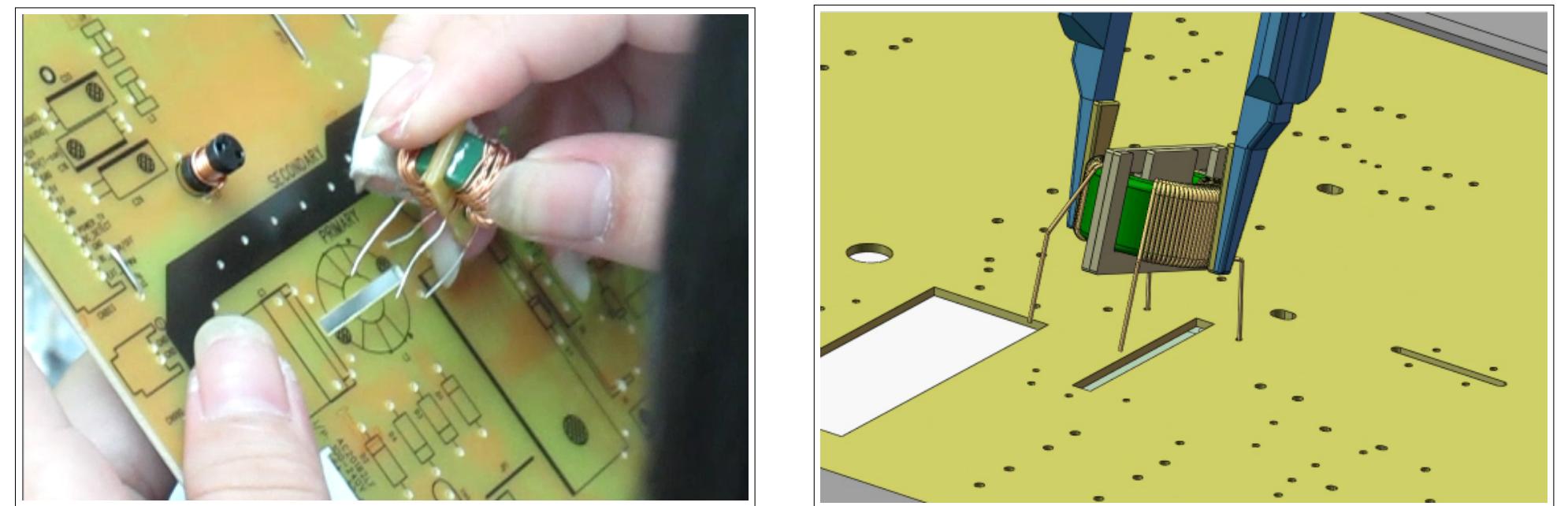
Industrial robotics focuses on:

- Optimal path control
- Precise task specification
- Precise body models

New robotics offers:

- Adaptability
- Flexibility
- Handling imperfect sensors
- Handling imperfect actuators
- Robustness

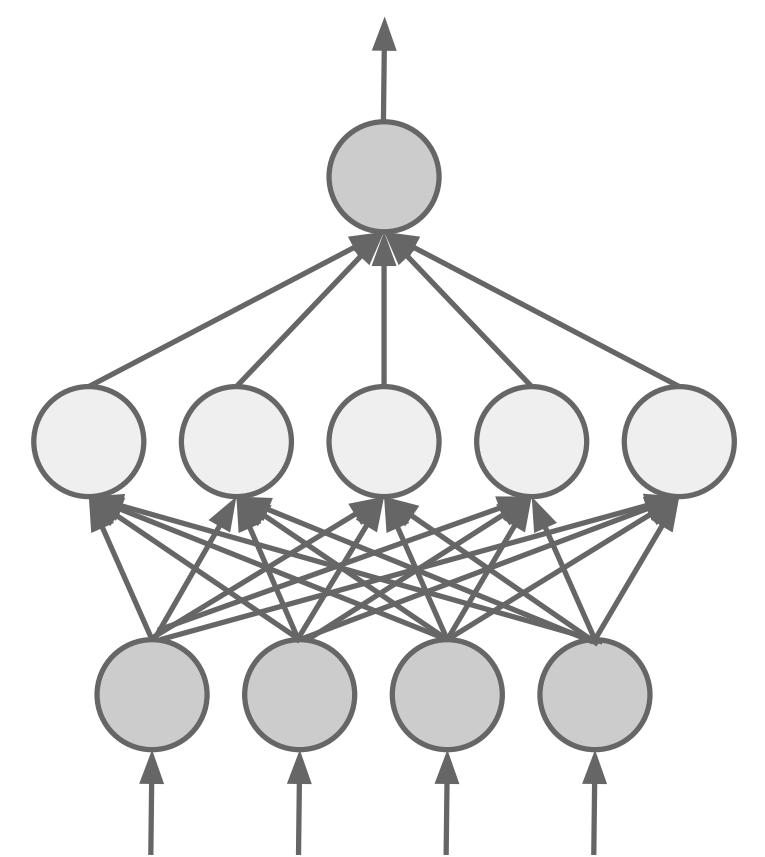
Flexible Manufacturing



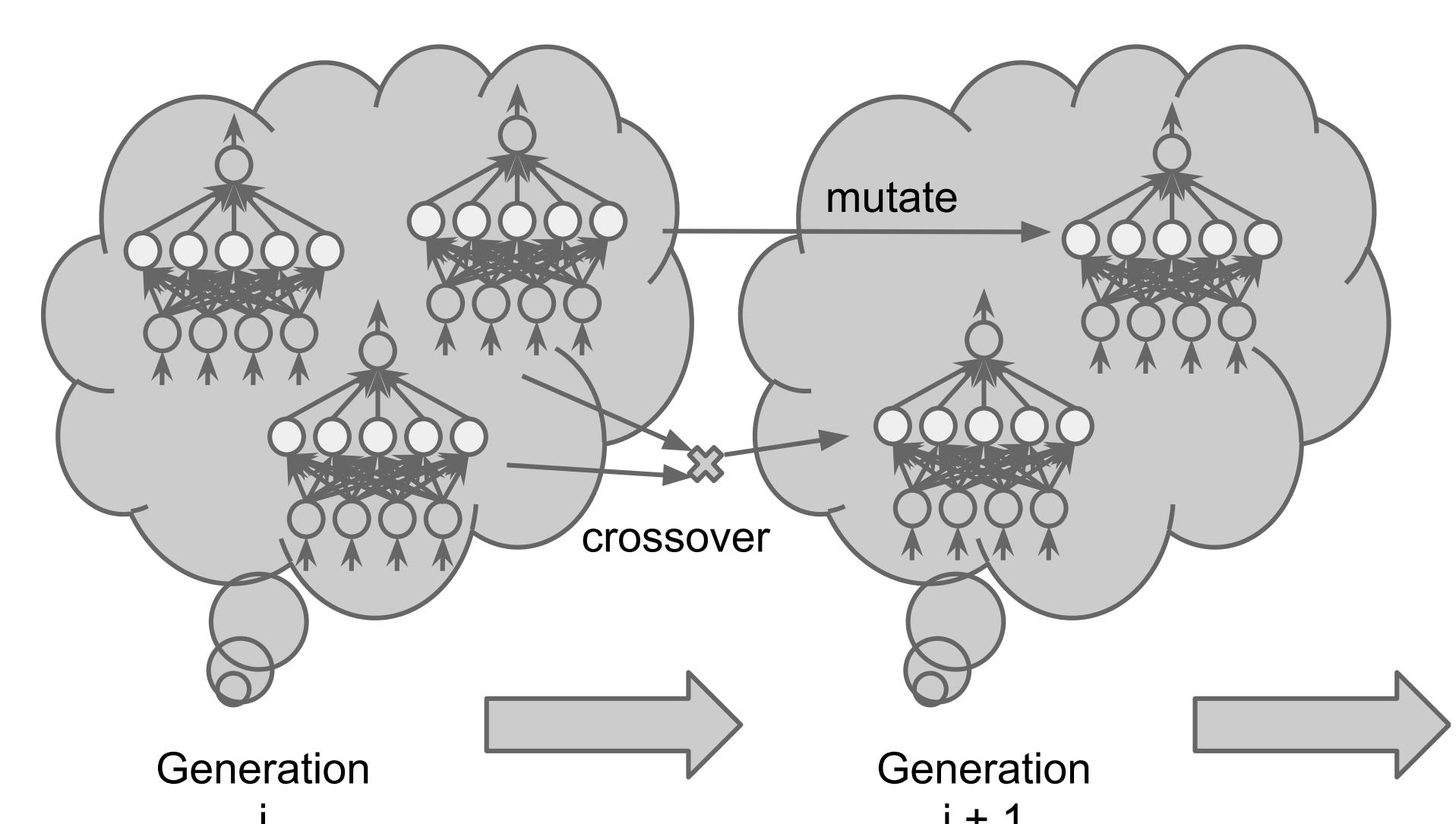
Need for robust control despite variations in the environment

Artificial Neural Networks

- Robust against noise
- Can function with incomplete inputs
- Nonlinear control
- Tested in many benchmarks
- Good choice for robotic control



Neuroevolution



With neuroevolution, there is no need for training the neural network. Instead, neuroevolution discovers a set of values for the weights by trying out random mutations and observing how they affect performance. All that is needed for neuroevolution to work is a measure of performance to evaluate the neural networks and select those which do better to produce the next generation through mutation and crossover operations.

NEAT

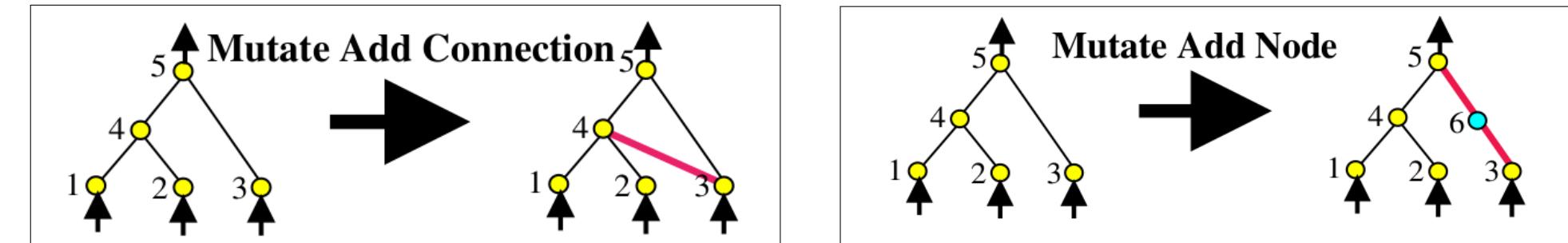
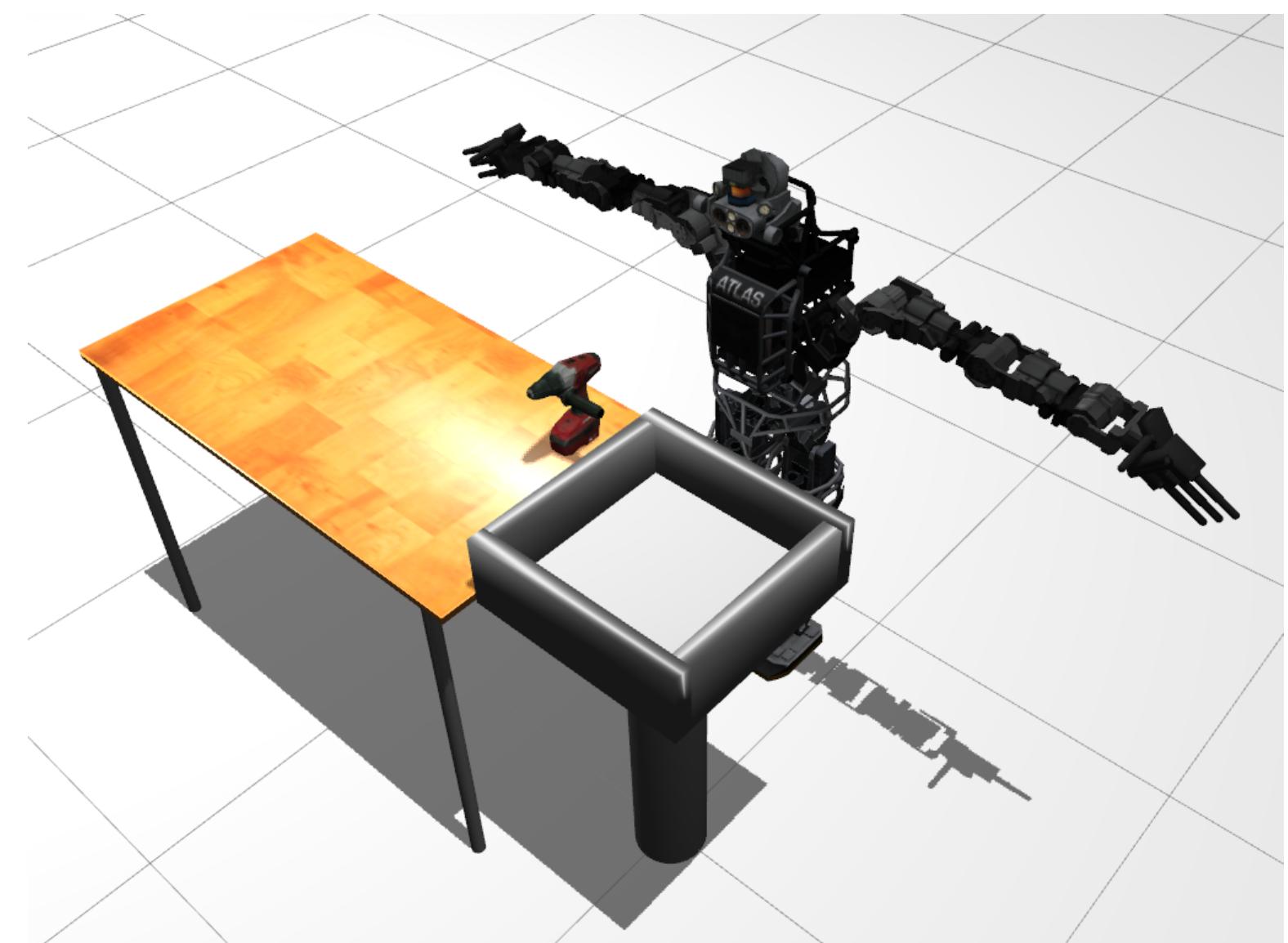


Figure: [Stanley and Miikkulainen, 2002]

Neuroevolution of Augmenting Topologies:

- No need to design a particular architecture
- Start with minimal topologies
- Can find topologies with right level of complexity

Simulation Task



- Controlling 6 joints in one arm
- Objective is to move all joints to requested angles and maintain their positions

Initial Network Architecture

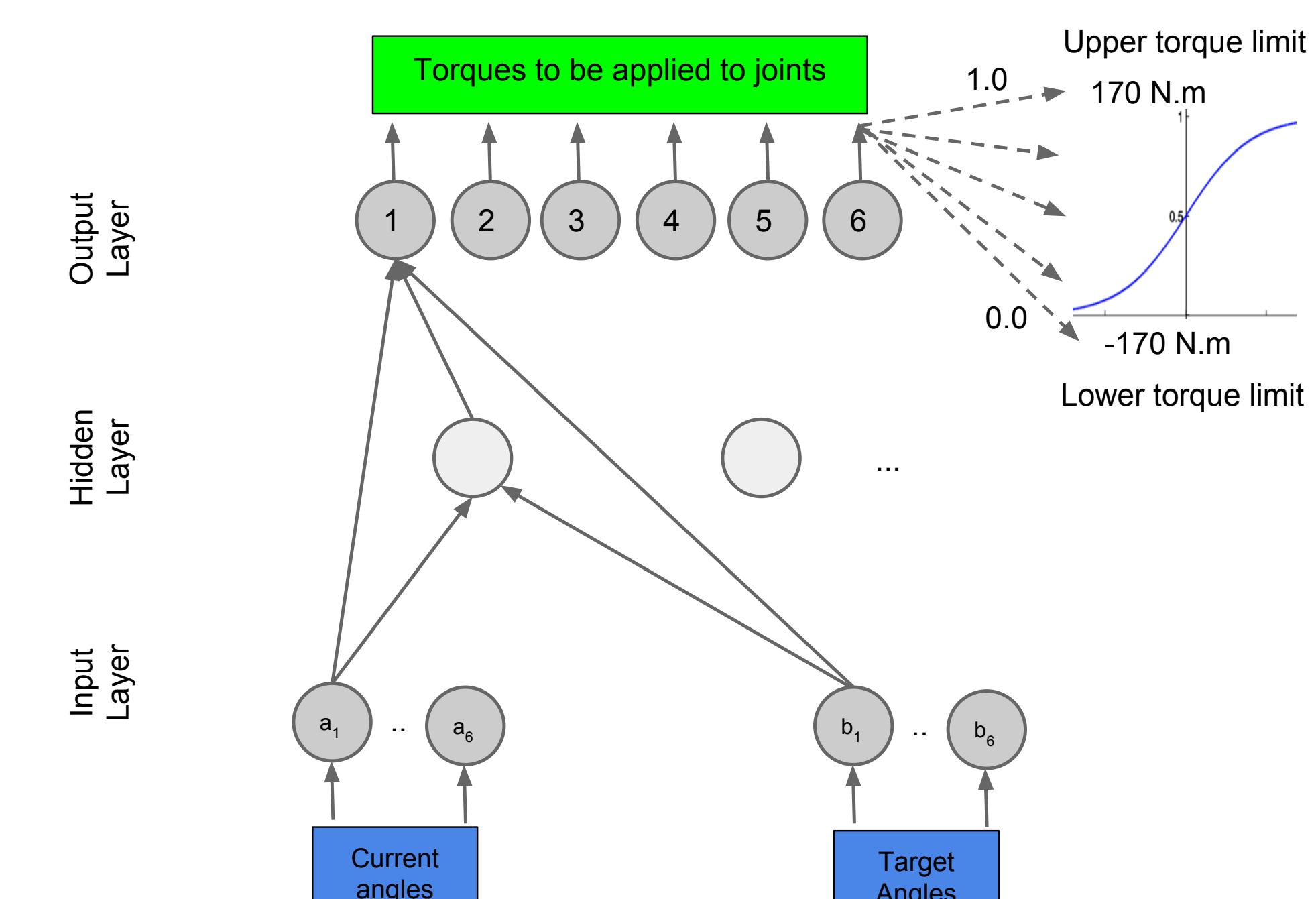


Figure: Neural network architecture corresponding to the initial genome

Experiment Results

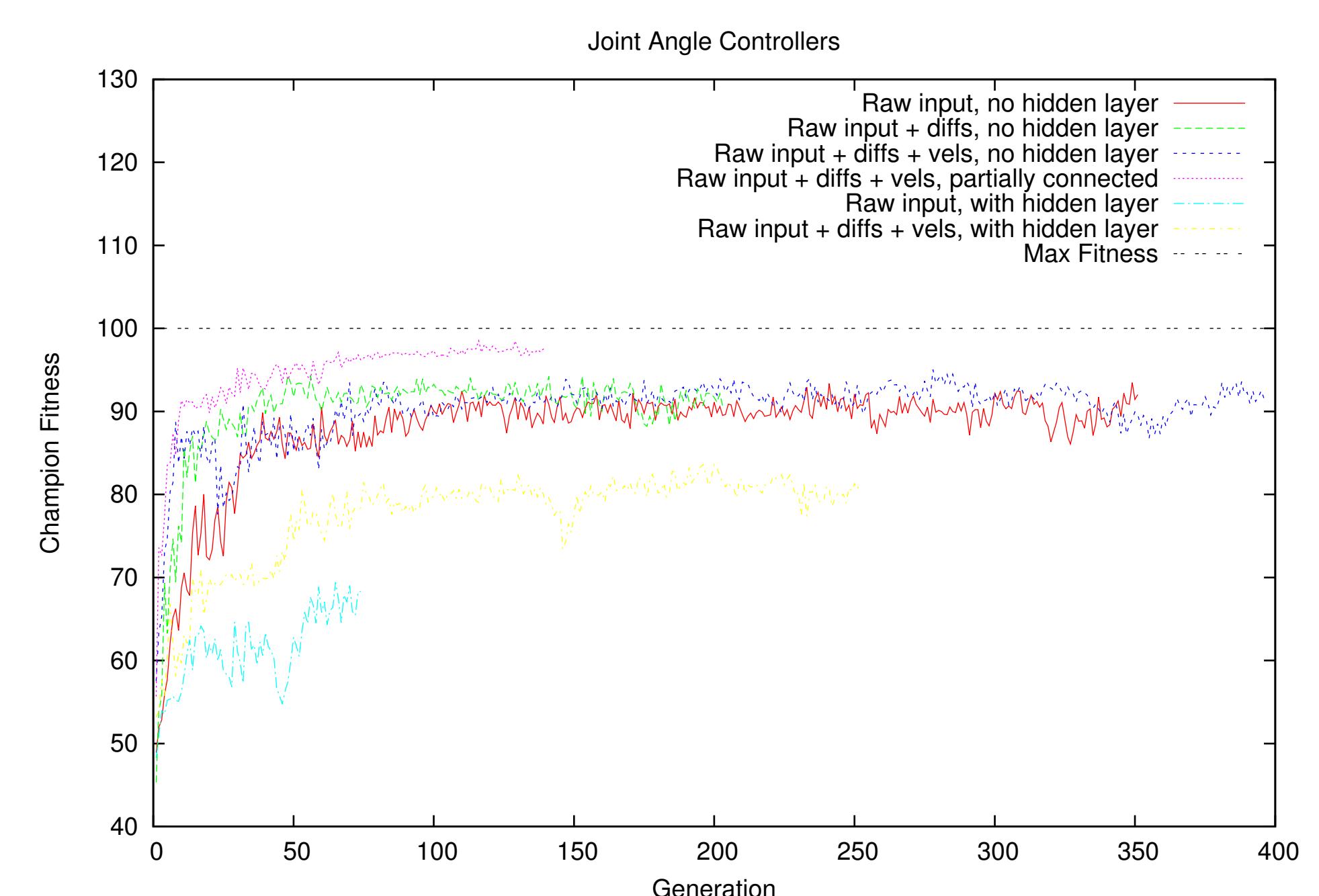
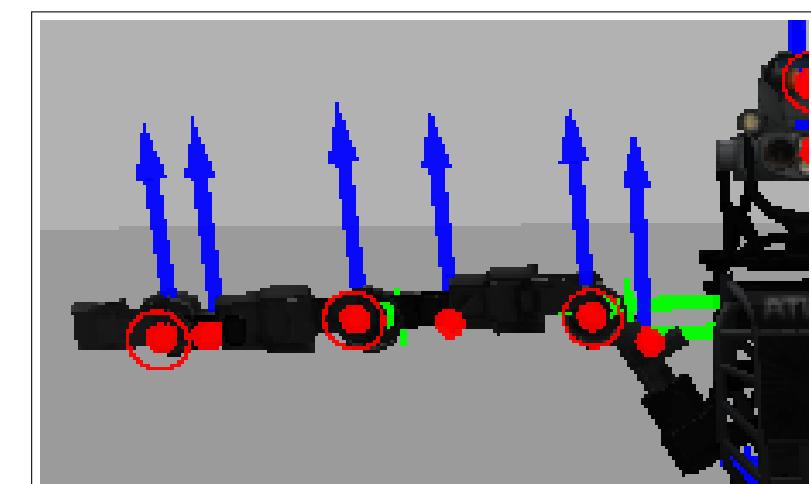


Figure: Varying network inputs and initial hidden layer



Figure: Varying network outputs

Future Work



- Evolve continuous-time recurrent neural networks: Since they model dynamical systems they may generate smoother movements
- Use controller designs where the network output controls the joints indirectly through predefined actions. e.g. accelerate/decelerate joint
- Evolve controllers for complex multi-step behaviors: Most robotic tasks require a sequence of steps to be taken, e.g. approaching a drill, picking it up, moving it to a bin, and letting go.